

## REMARKS

Applicant requests reconsideration and favorable action in view of the above amendments and the following remarks.

The present invention relates to a high precision force and displacement measuring device adapted to operate in at least two directions. The device includes a signal multiplexing scheme providing multiple signal channels to be transmitted through a single pick-up plate and sense amplifier, while maintaining high isolation between the channels, as well as identical electrical response characteristics of all channels. The device may be used in conjunction with a movable stage (such as on an optical microscope) to perform mechanical measurements on Micro Electro-Mechanical Systems (MEMS) devices.

Applicant has requested amendment to the claims as shown in the Appendix. The amendments to the various claims 1, 2, 4, 5, 6, 8-12, 15-19, 21, 22, 24-37, 39, 41-57 find antecedent basis in the specification as originally filed.

For example, the language in claim 1 " electrode means comprising a center electrode assembly including a center electrode and a plurality of support springs engaging and supporting said center electrode, said support springs comprising planar springs" is supported at page 11, line 21 and page 12 line 1 in the specification. Also, the originally filed claim 1 contained the language "a plurality of support springs engaging and supporting said center electrode, said support springs comprising planar springs". The language "said drive plates comprising an electroconductive material disposed on an aluminum oxide substrate" is supported at page 12 lines 12-21 and

page 2, lines 1-4 in the specification, and in originally filed claim 13 (now deleted): “said drive plates comprise an electroconductive disposed on an aluminum oxide substrate”.

The language in claim 2 “eight plates, four of said plates being disposed on each side of said center electrode” is supported at page 11, lines 12-17 in the specification.

The language in claim 5 “disposed on an aluminum oxide substrate” is supported at page 13, lines 2-4 in the specification, and in originally filed claim 13 (now deleted): “...disposed on an aluminum oxide substrate”.

The language “(a center electrode) assembly including a center electrode and a plurality of support springs engaging and supporting said center electrode, said support springs comprising planar springs” is supported at page 11, line 21 and page 12 line 1 in the specification. Also, the originally filed claim 1 contained the language “a plurality of support springs engaging and supporting said center electrode, said support springs comprising planar springs”.

The language in claim 6 “each of said upper and lower drive plate electrode assemblies include four plates” is supported at page 11, lines 14-17 in the specification.

The language in claim 8 “(support springs) of said center electrode assembly lie in a single (plane)” is supported at page 5, lines 16, 17 in the specification.

The language in claim 10 “metal foil of said center electrode assembly (comprises high strength beryllium copper alloy)” is supported at page 12 lines 3, 4 and 8, 9 in the specification.

The language in claim 11 “center electrode assembly is (formed from a single sheet of foil)” is supported at page 12, lines 3, 4 in the specification.

The language in claim 12 “center electrode assembly is (formed from a single

sheet of foil...)” is supported at page 12, lines 3, 4 in the specification.

The language in claim 17 “(drive plate) electrode assembly” and “center (electrode) assembly” is supported at page 12, line 12 in the specification.

The language in claim 18 “ drive plate electrodes of said drive plate electrode assemblies (comprise copper foil...)” is supported at page 12, line 12 in the specification.

The language in claim 19 “A precision Multi-dimensional capacitive transducer comprising: a plurality of drive plates, said plates being composed of electrically conductive material” is supported at page 11, lines 14-17 and page 12, lines 12-16, as well as in originally filed claim 1: “A precision Multi-dimensional capacitive transducer comprising: (a pickup plate;) a plurality of drive plates ... each of said drive plates being composed of an electrically conductive material;” The language “pickup electrode means movably mounted relative to said drive plates” is supported at page 2, lines 11-13 in the specification. The language “said drive plates being operatively grouped into pairs” is supported at page 6, line 21 and page 7, line 1 in the specification. The language “(one sub-channel pulse) of said main channel operative on a first drive plate of said drive plate pair, with remaining sub-channel pulse of said main channel simultaneously operative on remaining drive plate of said drive plate pair” is supported at page 18, lines 18-20, and in Fig.10 in the specification. The language “with each main channel dedicated to a particular drive plate pair,” is supported at page 18, lines 18-21 and page 19, line 1 in the specification. The language “(sampling means for synchronously demodulating) and demultiplexing (the signal)” is supported at page 19 lines 6-21 and p20, lines 1-7 in the specification. Applicant believes those skilled in the

art would understand the implicit nature of the demultiplexing associated with the sampling means for synchronously demodulating the signal, but adding “and demultiplexing” between “demodulating” and “the signal” would provide further clarification. The dictionary gives this definition for “multiplex”: 2 Telecom. Designing a system for the simultaneous transmission of two or more messages in either or both directions over the same wire, as in telegraphy or telephony. A more modern definition would be combining two or more signals for simultaneous transmission (the transmission means could be by a wire, or by fiber optic cable, wireless RF transmission or any other means capable of transmitting a signal from one location to another). The reverse operation, demultiplexing, is used at the receiving end of the transmission to separate the combined signal back into the individual signals, or channels. This is described by applicant on P16, lines 20, 21: “...output of amplifier 91 synchronously demodulated and multiplexed to separate the signals into four separate differential channels by eight channel analog multiplexer 96.” Although applicant used the term “multiplexer”, rather than the term “demultiplexer”, The actual function as a demultiplexer is accurately described in the specification. Applicant described item 96 (74HC4051) as an “eight channel analog multiplexer” as that is the descriptive title given the part in the data sheet from National Semiconductor. It would, however, be more accurate to describe it as an “eight channel analog multiplexer/demultiplexer”, as it can be used either way, depending on which terminals are used as inputs and which are used as outputs. Another manufacture of the part, SGS Thompson Microelectronics, describes the part more clearly as a multiplexer/demultiplexer. The language “(pickup) electrode means” is supported at page 2, lines 11, 12 in the

specification. The language “(each channel) operatively associated with a particular drive plate pair” is supported at page 18, lines 18-21 and page 19, line 1 in the specification. The language “(drive plate) pair” is supported at page 18, line 20 in the specification. The language “in said multiplexed sequence” is supported at page 20, line 6 in the specification.

The language in claim 21 “(drive plates comprise) eight (plates)” is supported at page 19, line 19 in the specification (since four pair = eight).

The language in claim 22 “(displacement of the pickup electrode) means relative to the drive plates” is supported at page 2, lines 11-13 in the specification.

The language in claim 24 “(drive plates comprise) eight (plates)” is supported at page 19, line 19 in the specification (since four pair = eight).

The language in claim 25 “mounted in said objective turret, ” is supported at page 24, lines 20, 21 and page 25, lines 4, 5 in the specification. The language “a precision Multi-dimensional capacitive transducer comprising: a plurality of drive plates, said drive plates being composed of electrically conductive material” is supported at page 11, lines 14-17 and page 12, lines 12-16, as well as in originally filed claim 1: “A precision Multi-dimensional capacitive transducer comprising: (a pickup plate;) a plurality of drive plates ... each of said drive plates being composed of an electrically conductive material;” The language “pickup electrode means movably mounted relative to said drive plates” is supported at page 2, lines 11-13 in the specification.

The language in claim 26 “electrical circuit means for applying electrical drive pulses to said drive plates, said drive plates being operatively grouped into pairs” is supported at page 7, line 1 in the specification. The language “said pulses having a

frequency  $F$ , and a pulse width  $T$  of approximately  $1/F$  divided by the total number of drive plates" is supported at page 18 lines 6, 7, 14, 15 in the specification, for the description of the device with eight drive plates, and for the device with 6 drive plates, the specification on page 24, lines 15-17 states that the circuitry is the same except for the elimination of one of the four channels, thus  $T=1/6F$ . The language "said drive pulses being grouped into one main channel per operative drive plate pair" is supported at page 7, lines 1-3 and page 18, lines 18, 19, and Fig 10 in the specification. The language "each main channel consisting of two sub-channel pulses, one sub-channel pulse of said main channel operative on a first drive plate of said drive plate pair, with remaining sub-channel pulse of said main channel simultaneously operative on remaining drive plate of said drive plate pair, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with each main channel dedicated to a particular drive plate pair, and with said main channels being spaced apart in time by approximately the pulse width  $T$ " is supported at page 18 lines 2-21, page 19 lines 1-2, and Fig. 10 in the specification. The language "sampling means for synchronously demodulating and demultiplexing the signal on the pickup electrode means into one channel per drive plate pair, each channel consisting of two sub-channel signals, each channel operatively associated with a particular drive plate pair" is supported at page 19, lines 6-17, Fig 10 and Fig 9a in the specification. The language "timing means for controlling said sampling means such that each first sub-channel is sampled during the time period that the drive pulse is applied to the corresponding drive plate" is supported at page 19, lines 6-17 and Fig 9a in the specification. The language "and each second sub-channel is sampled after the drive pulse corresponding to that drive

plate has ended, and before the drive pulse corresponding to the next channel in said multiplexed sequence is applied” is supported at page 20, lines 7-9 in the specification. The language “storage means for each sub-channel” is supported at page 20, lines 6-7 in the specification. The language “differential amplifier means to convert each of the sub-channel signal pairs into single main channel signals” is supported at page 17 lines 2-4 in the specification.

The language in claim 27 “ main channel signals generated by said differential amplifier means constitutes the outputs of the transducer” is supported at page 3, lines 6-9 in the specification.

The language in claim 28 “said plurality of drive plates consists of eight plates” is supported at page 16, line 9 in the specification. The language “the number of said main channel signals being four,” is supported at page 16, line 21 in the specification. The language “electrical circuit means summing all four main channel signals together, said summed signal constituting the Z-axis output signal; electrical circuit means generating the difference of two of said main channels, said difference signal constituting the X-axis output signal; electrical circuit means generating the difference of the two main channels not used to generate the X-axis output, said difference signal constituting the Y-axis output signal.” is supported at page 22 lines 12-19 in the specification.

The language in claim 29 “each of said main channel signals generated by said differential amplifier means are connected to feedback circuit means which produce feedback signals which control the amplitude of the drive plate pulses in response to displacement of the pickup electrode means relative to the drive plate electrodes, such

that the induced voltage on the pickup electrode means is forced to zero, and the feedback signals generated by said feedback circuit means are proportional to the displacement of the pickup electrode means relative to the drive plate electrodes” is supported at page 3, lines 15-19 and page 21, line 5 to page 22 line 11 in the specification.

The language in claim 30 “wherein said feedback signals constitute the outputs of the transducer” is supported at page 24, lines 14, 15 in the specification.

The language in claim 31 “wherein said plurality of drive plates consists of eight plates” is supported at page 16, line 9 in the specification. The language “the number of said main channel signals being four” is supported at page 16, line 21 in the specification. The language “the number of said feedback signals being four” is supported at page 21 line 5 to page 22 line 11 in the specification. The language “Electrical circuit means summing all four feedback signals together, said summed signal constituting the Z-axis output of the transducer; electrical circuit means generating the difference of two of said feedback signals, said difference signal constituting the X-axis output signal of the transducer; electrical circuit means generating the difference of the two feedback signals not used to generate the X-axis output, said difference signal constituting the Y-axis output signal of the transducer” is supported at page 22 lines 12-19 in the specification.

The language in claim 32 “an optical microscope apparatus having a stage providing X-Y motion” is supported at page 8, line 16 and page 9 line 2 in the specification. The language “focusing means providing Z-axis motion” is supported at page 9, lines 1, 2 in the specification. The language “a multi-position objective turret

containing one or more optical objectives” is supported at page 8 lines 18-20 in the specification. The language “means for multi-axis force and/or displacement measurement mounted in said objective turret, said means for multi-axis force and/or displacement measurement including a precision Multi-dimensional capacitive transducer” is supported at page 8, lines 16-21 and page 9, lines 1-2 in the specification. The language “comprising: a plurality of drive plates, said drive plates being composed of electrically conductive material” is supported at page 11, lines 14-17 and page 12, lines 12-16, as well as in originally filed claim 1: “a plurality of drive plates ... each of said drive plates being composed of an electrically conductive material;” The language “pickup electrode means movably mounted relative to said drive plates” is supported at page 2, lines 11-13 in the specification. The language “probe tip means for transmitting force and/or displacement between said transducer and a sample,” is supported at page 6, lines 8-9 in the specification. The language “engage the probe tip with the sample” is supported at page 25, lines 5-7 in the specification.

The language in claim 33 “head/slider/suspension assemblies” is supported at page 14, line 19 in the specification. The language “test surface” is supported at page 15, line 17 in the specification.

The language in claim 34 “A precision Multi-dimensional capacitive transducer comprising:” is supported at page 1, line 5 in the specification, as well as in originally filed claim 1: “A precision Multi-dimensional capacitive transducer comprising:”. The language “at least one drive plate electrode assembly” is supported at page 12, line 12 in the specification. The language “said assembly including a plurality of drive plates,

said drive plates being composed of electrically conductive material” is supported at page 11, lines 14-17 and page 12, lines 12-16, as well as in originally filed claim 5: “said upper assembly including a plurality of drive plates, said drive plates being composed of electrically conductive material”. The language “said assembly also including insulating substrate means holding said drive plates of said assembly fixed with respect to each other;” is supported at page 12, lines 12-15 and page 5, lines 10-11 in the specification. The language “spacer means disposed on said at least one drive plate assembly” is supported at page 13, lines 9-11 in the specification.

The language “pickup electrode means operatively engaging said at least one drive plate electrode assembly;” is supported at page 6, lines 15, 16 and page 2, lines 11, 12 in the specification. The language “at least one support spring, said spring including a main central section and two ends, a first end proximate to and mechanically engaging and supporting said pickup electrode, remaining end engaged and supported by said spacer means, said remaining end being wider than said main central section, said remaining end section proximate said spacer means extending at least  $\frac{1}{4}$  of the width of said main section, before contacting said spacer means” is supported at page 13, lines 12-16, and Fig. 8 in the specification.

The language in claim 35 “said spacer means and ends proximate said spacer means of said at least one support spring, (includes additional support means)” is supported at page 13, lines 16-19, and Fig. 8 in the specification.

The language in claim 37 “ three main channels, one (per operative drive plate pair)” is supported at page 24, lines 11-16 in the specification.

The language “(one sub-channel pulse) of said main channel operative on one drive plate of said drive plate pair, with remaining sub-channel pulse of said main channel simultaneously operative on remaining drive plate of said operative drive plate pair” is supported at page 18, lines 18-20, and in Fig.10 in the specification. The language “with each main channel dedicated to a particular operative drive plate pair” is supported at page 18, lines 18-21 and page 19, line 1 in the specification. The language “(synchronously demodulating) and demultiplexing” is supported at page 19 lines 6-21 and p20, lines 1-7 in the specification, with further information given under claim 19 support. The language “each channel operatively associated with a particular operative drive plate pair” is supported at page 18, lines 18-21 and page 19, line 1 in the specification. The language “in said multiplexed sequence” is supported at page 20, line 6 in the specification. The language “three (sub-channel signal pairs)” is supported at page 24, lines 11-16 in the specification.

The language in claim 41 “wherein said test surface comprises a rigid disk of a magnetic disk drive data storage device.” is supported at page 14, lines 18-19 in the specification.

The language in claim 42 “wherein said pickup electrode means further comprises a hollow box shaped structure.” is supported at page 24, lines 9, 10 in the specification.

The language in claim 43 “wherein said pickup electrode means further comprises three interleaved flat plates” is supported at page 24, lines 10, 11 in the specification.

The language in claim 44 “pickup electrode means comprising a centrally located

center electrode" is supported at page 2, lines 9-13 and page 5, lines 8-12 in the specification. The language "a plurality of pairs of drive plates, one of each of said pairs of drive plates being disposed on each of opposing sides of said center electrode," is supported at page 5, lines 8-10 in the specification. The language "means for supporting each of said drive plates, each of said drive plates being composed of an electrically conductive material" is supported at page 5, lines 10-11 in the specification. The language "a plurality of support springs engaging and supporting said center electrode, said support springs comprising planar springs" is supported at page 11, line 21 and page 12 line 1 in the specification. Also, the originally filed claim 1 contained the language "a plurality of support springs engaging and supporting said center electrode, said support springs comprising planar springs". The language "electrical circuit means for applying electrical drive pulses to said drive plates" is supported at page 7, line 1 in the specification. The language "said pulses having a frequency  $F$ , and a pulse width  $T$  of approximately  $1/F$  divided by the total number of drive plates" is supported at page 18 lines 6, 7, 14, 15 in the specification, for the description of the device with eight drive plates, and for the device with 6 drive plates, the specification on page 24, lines 15-17 states that the circuitry is the same except for the elimination of one of the four channels, thus  $T=1/6F$ . The language "said drive pulses being grouped into one main channel per operative upper/lower drive plate pair" is supported at page 7, lines 1-3 and page 18, lines 18, 19, and Fig 10 in the specification. The language "each main channel consisting of two sub-channel pulses, one sub-channel pulse operative on each drive plate, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with said main

channels being spaced apart in time by approximately the pulse width  $T$ , and said two sub-channel signals of the active main channel being applied simultaneously to the top/bottom drive plate pair;" is supported at page 18 lines 2-21, page 19 lines 1-2, and Fig. 10 in the specification.

The language "sampling means for synchronously demodulating and demultiplexing the signal on the pickup plate into one channel per drive plate pair, each channel consisting of two sub-channel signals;" is supported at page 19, lines 6-17, Fig 10 and Fig 9a in the specification. The language "timing means for controlling said sampling means such that each first sub-channel is sampled during the time period that the drive pulse is applied to the corresponding drive plate" is supported at page 19, lines 6-17 and Fig 9a in the specification. The language "and each second sub-channel is sampled after the drive pulse corresponding to that drive plate has ended, and before the drive pulse corresponding to the next channel is applied" is supported at page 20, lines 7-9 in the specification. The language "storage means for each sub-channel" is supported at page 20, lines 6-7 in the specification. The language "differential amplifier means to convert each of the sub-channel signal pairs into single main channel signals" is supported at page 17 lines 2-4 in the specification.

The language in claim 45 "A precision multi-dimensional capacitive transducer comprising: a lower drive plate electrode assembly, said lower assembly including a plurality of drive plates, said drive plates being composed of electrically conductive material; an upper drive plate electrode assembly, said upper assembly including a plurality of drive plates, said drive plates being composed of electrically conductive

material;" is supported in originally filed claim 5, as well as page 5, lines 8-12 in the specification. The language "pickup electrode means comprising a center electrode" is supported at page 2, lines 9-12 and page 5, lines 8-12 in the specification. The language "assembly including a center electrode and a plurality of support springs engaging and supporting said center electrode, said support springs comprising planar springs" is supported at page 5, lines 12-17 in the specification, and in originally filed claim 5. The language "said lower drive plate electrode assembly and said upper drive plate electrode assembly being disposed on opposing sides of said center electrode;" is supported at page 5, lines 8-10, page 11 lines 12-17 and originally filed claim 5, in the specification. The language "electrical circuit means for applying electrical drive pulses to said drive plates" is supported at page 7, line 1 in the specification. The language "said pulses having a frequency  $F$ , and a pulse width  $T$  of approximately  $1/F$  divided by the total number of drive plates" is supported at page 18 lines 6, 7, 14, 15 in the specification, for the description of the device with eight drive plates, and for the device with 6 drive plates, the specification on page 24, lines 15-17 states that the circuitry is the same except for the elimination of one of the four channels, thus  $T=1/6F$ . The language "said drive pulses being grouped into one main channel per operative upper/lower drive plate pair" is supported at page 7, lines 1-3 and page 18, lines 18, 19, and Fig 10 in the specification. The language "each main channel consisting of two sub-channel pulses, one sub-channel pulse operative on each drive plate, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with said main channels being spaced apart in time by approximately the pulse width  $T$ , and said two sub-channel signals of the active main channel being applied

simultaneously to the top/bottom drive plate pair;" is supported at page 18 lines 2-21, page 19 lines 1-2, and Fig. 10 in the specification. The language "sampling means for synchronously demodulating and demultiplexing the signal on the pickup plate into one channel per drive plate pair, each channel consisting of two sub-channel signals;" is supported at page 19, lines 6-17, Fig 10 and Fig 9a in the specification. The language "timing means for controlling said sampling means such that each first sub-channel is sampled during the time period that the drive pulse is applied to the corresponding drive plate" is supported at page 19, lines 6-17 and Fig 9a in the specification. The language "and each second sub-channel is sampled after the drive pulse corresponding to that drive plate has ended, and before the drive pulse corresponding to the next channel is applied" is supported at page 20, lines 7-9 in the specification. The language "storage means for each sub-channel" is supported at page 20, lines 6-7 in the specification. The language "differential amplifier means to convert each of the sub-channel signal pairs into single main channel signals" is supported at page 17 lines 2-4 in the specification.

The language in claim 46 "wherein said pickup electrode means comprises a centrally located center electrode, with said drive plates comprising two groups disposed on opposing sides of said center electrode." is supported at page 2, lines 9-13 and page 5, lines 8-12 in the specification.

The language in claim 47 "wherein said main channel signals generated by said differential amplifier means constitutes the outputs of the transducer" is supported at page 3, lines 6-9 in the specification.

The language in claim 48 "wherein said drive plate electrodes comprise eight

plates, with said two groups of drive plate electrodes comprising four plates each” is supported at page 11, lines 14-17 in the specification.

The language “electrical circuit means summing all four main channel signals together, said summed signal constituting the Z-axis output signal; electrical circuit means generating the difference of two of said main channels, said difference signal constituting the X-axis output signal; and electrical circuit means generating the difference of the two main channel signals not used to generate the X-axis output, said difference signal constituting the Y-axis output signal.” is supported at page 22 lines 12-19 in the specification.

The language in claim 49 “wherein each of said main channel signals generated by said differential amplifier means are connected to feedback circuit means which produce feedback signals which control the amplitude of the drive plate pulses in response to displacement of the pickup electrode means relative to the drive plate electrodes, such that the induced voltage on the pickup electrode means is forced to zero, and the feedback signals generated by said feedback circuit means are proportional to the displacement of the pickup electrode means relative to the drive plate electrodes.” is supported at page 3, lines 15-19 and page 21, line 5 to page 22 line 11 in the specification.

The language in claim 50 “wherein said feedback signals constitute the outputs of the transducer” is supported at page 24, lines 14, 15 in the specification.

The language in claim 51 “ wherein said drive plate electrodes comprise eight plates, with said two groups of drive plate electrodes comprising four plates each” is

supported at page 11, lines 14-17 in the specification.

The language “electrical circuit means summing all four feedback signals together, said summed signal constituting the Z-axis output signal; electrical circuit means generating the difference of two of said feedback signals, said difference signal constituting the X-axis output signal; and electrical circuit means generating the difference of the two feedback signals not used to generate the X-axis output, said difference signal constituting the Y-axis output signal.” is supported at page 22 lines 12-19 in the specification.

The language in claim 52 “said insulating substrate means of said at least one drive plate electrode assembly is composed of aluminum oxide.” is supported at page 13, lines 2-4 in the specification, and in originally filed claim 13 (now deleted): “...disposed on an aluminum oxide substrate”.

The language in claim 53 “wherein the at least one support spring is composed of a material having a thermal expansion coefficient similar to aluminum oxide” is supported at page 13, lines 5-7 in the specification, as well as in originally filed claim 15.

The language in claim 54 “ wherein the at least one support spring is composed of molybdenum metal” is supported at page 13, lines 7, 8 in the specification, as well as in originally filed claim 16.

The language in claim 55 “said insulating substrate means of said at least one drive plate electrode assembly is composed of aluminum oxide.” is supported at page 13, lines 2-4 in the specification, and in originally filed claim 13 (now deleted): “...disposed on an aluminum oxide substrate”.

The language in claim 56 "wherein the at least one support spring and said spacer means are composed of a material having a thermal expansion coefficient similar to aluminum oxide" is supported at page 13, lines 5-7 in the specification, as well as in originally filed claim 15.

The language in claim 57 " wherein the at least one support spring and said spacer means are composed of molybdenum metal." is supported at page 13, lines 7, 8 in the specification, as well as in originally filed claim 16.

The present invention is patentably distinct in view of the prior art for the following reasons:

Claim 1 requires:

. . . said drive plates comprising an electroconductive material disposed on an  
aluminum oxide substrate. . . .

The prior art fails to teach or make obvious drive plates which have an electroconductive material disposed on an aluminum oxide substrate. Aluminum oxide is a more mechanically stable material than the glass fiber/epoxy printed circuit board material. The stiffness is about 50 times greater and the thermal expansion coefficient is about 1/3, so the aluminum oxide substrate will distort much less under the influence of mechanical and thermal stresses than the glass fiber/epoxy material, resulting is a more stable and accurate transducer. The invention defined in Claim 1 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 2 requires:

. . . said drive plates comprise eight plates, four of said plates being  
disposed on each side of said center electrode.

The prior art fail to teach or make obvious drive plates including eight plates with four of the plates located on each side of the center electrode. By individually sensing the signals generated by eight drive plates it is possible to determine three axis motion on a single pickup plate. The invention defined in Claim 2 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 5 requires:

. . . said drive plates being composed of electrically conductive material disposed  
on an aluminum oxide substrate. . . .

The prior art fail to teach or make obvious drive plates which have an electroconductive material disposed on an aluminum oxide substrate. Aluminum oxide is a more mechanically stable material than the glass fiber/epoxy printed circuit board material. The stiffness is about 50 times greater and the thermal expansion coefficient is about 1/3, so the aluminum oxide substrate will distort much less under the influence of mechanical and thermal stresses than the glass fiber/epoxy material, resulting is a more stable and accurate transducer. The invention defined in Claim 5 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 6 requires:

. . . each of said upper and lower drive plate electrode assemblies include four plates.

The prior art fail to teach or make obvious drive plate electrode assemblies with four plates. Two drive plate assemblies of four plates each, on opposing sides of the center electrode, is the preferred configuration (when the total number is eight and the center electrode has two active sides) to minimize the required size of the center electrode as well as the entire transducer. The invention defined in Claim 6 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 19 requires:

. . . said pulses having a frequency  $F$ , and a pulse width  $T$  of approximately  $1/F$  divided by the total number of drive plates, . . . one sub-channel pulse of said main channel operative on a first drive plate of said drive plate pair, with remaining sub-channel pulse of said main

channel simultaneously operative on remaining drive plate of said drive plate pair, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with each main channel dedicated to a particular drive plate pair, and with said main channels being spaced apart in time by approximately the pulse width  $T$ , . . . sampling means for synchronously demodulating and demultiplexing the signal on the [pickup plate] pickup electrode means into one channel per drive plate pair, . . . timing means for controlling said sampling means such that each first sub-channel is sampled during the time period that the drive pulse is applied to the corresponding drive plate pair and each second sub-channel is sampled after the drive pulse corresponding to that drive plate has ended, and before the drive pulse corresponding to the next channel in said multiplexed sequence is applied. . .

The prior art fail to teach or make such circuitry obvious. The pulse width of approximately  $1/F$  divided by the number of drive plates allows the multiple channel drive plate signals to be multiplexed onto a single pickup electrode. The one sub-channel pulse of said main channel operative on a first drive plate of said drive plate pair, with remaining sub-channel pulse of said main channel simultaneously operative on remaining drive plate of said drive plate pair, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with each main channel dedicated to a particular drive plate pair, and with said main channels being spaced apart in time by approximately the pulse width  $T$ , allows one sample of the

signal on the pickup electrode to be made while the drive plate pulse for that channel is present, and another sample for that channel to be made with no drive plate pulse present, providing a differential measurement of the amplitude (a measure of the displacement of the pickup electrode) independently for each channel. Differential measurements are helpful in rejecting some types of noise. The invention defined in Claim 19 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 21 requires:

. . . electrical circuit means summing all four main channel signals together, said summed signal constituting the Z-axis output signal; electrical circuit means generating the difference of two of said main channels, said difference signal constituting the X-axis output signal; and electrical circuit means generating the difference of the two main channel signals not used to generate the X-axis output, said difference signal constituting the Y-axis output signal.

The prior art fail to teach or make such circuitry obvious. The circuitry decodes the four channel signals representing the local displacement of the pickup electrode, into three channels representing the displacement of a probe attached to the pickup electrode, in three orthogonal axes, which is more useful than the four channel signal, in which the individual channels do not directly correspond with physical axes of the transducer. The invention defined in Claim 21 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 22 requires:

. . . each of said main channel signals generated by said differential amplifier means are connected to feedback circuit means which produce feedback signals which control the amplitude of the drive plate pulses in response to displacement of the pickup electrode means relative to the drive plate electrodes, such that the induced voltage on the pickup electrode means is forced to zero, and the feedback signals generated by said feedback circuit means are proportional to the displacement of the pickup electrode means relative to the drive plate electrodes.

The prior art fail to teach or make such circuitry obvious. The feedback circuitry reduces the effect of parasitic capacitance on the linearity of the output Vs displacement signal. This is especially important here, where signals from multiple drive plate pairs are applied to a single pickup electrode, resulting in a large parasitic capacitance, in fact the parasitic capacitance in this case is several times larger than the sense capacitance, so the non-linearity without the feedback system would be very large, on the order of 50 - 75%. The invention defined in Claim 22 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 24.

. . . said drive plate electrodes comprise eight plates, . . . electrical circuit means summing all four feedback signals together, said summed signal constituting the Z-axis output signal; electrical circuit means generating the difference of two of said feedback signals, said difference signal constituting the X-axis output signal;

and electrical circuit means generating the difference of the two feedback signals not used to generate the X-axis output, said difference signal constituting the Y-axis output signal.

The prior art fail to teach or make such circuitry obvious. The circuitry decodes the four channel signals representing the local displacement of the pickup electrode, into three channels representing the displacement of a probe attached to the pickup electrode, in three orthogonal axes, which is more useful than the four channel signal, in which the individual channels do not directly correspond with physical axes of the transducer. The invention defined in Claim 24 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 25 requires:

. . . means for multi-axis force and/or displacement measurement  
mounted in said objective turret. . . .

The prior art fail to teach or make such mechanism obvious. This allows an optical microscope to be upgraded to include the capability of performing nano/microindentation hardness testing, scratch testing, profilometry and similar functions at far less cost than purchasing separate stand alone tools. The invention defined in Claim 25 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 26 requires:

. . . a pulse width  $T$  of approximately  $1/F$  divided by the total number of drive plates, said drive pulses being grouped into one main channel per

operative drive plate pair, each main channel consisting of two sub-channel pulses, one sub-channel pulse of said main channel operative on a first drive plate of said drive plate pair, with remaining sub-channel pulse of said main channel simultaneously operative on remaining drive plate of said drive plate pair, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with each main channel dedicated to a particular drive plate pair, and with said main channels being spaced apart in time by approximately the pulse width  $T$ ; sampling means for synchronously demodulating and demultiplexing the signal on the pickup electrode means into one channel per drive plate pair, each channel consisting of two sub-channel signals, each channel operatively associated with a particular drive plate pair; timing means for controlling said sampling means such that each first sub-channel is sampled during the time period that the drive pulse is applied to the corresponding drive plate and each second sub-channel is sampled after the drive pulse corresponding to that drive plate has ended, and before the drive pulse corresponding to the next channel in said multiplexed sequence is applied. . . .

The prior art fail to teach or make such circuitry obvious. The pulse width of approximately  $1/F$  divided by the number of drive plates allows the multiple channel drive plate signals to be multiplexed onto a single pickup electrode. The one sub-channel pulse of said main channel operative on a first drive plate of said drive plate

pair, with remaining sub-channel pulse of said main channel simultaneously operative on remaining drive plate of said drive plate pair, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with each main channel dedicated to a particular drive plate pair, and with said main channels being spaced apart in time by approximately the pulse width  $T$ , allows one sample of the signal on the pickup electrode to be made while the drive plate pulse for that channel is present, and another sample for that channel to be made with no drive plate pulse present, providing a differential measurement of the amplitude (a measure of the displacement of the pickup electrode) independently for each channel. Differential measurements are helpful in rejecting some types of noise. The invention defined in Claim 26 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 28 requires:

. . . said plurality of drive plates consists of eight plates, the number of said main channel signals being four, further including: electrical circuit means summing all four main channel signals together, said summed signal constituting the Z-axis output signal; electrical circuit means generating the difference of two of said main channels, said difference signal constituting the X-axis output signal; electrical circuit means generating the difference of the two main channels not used to generate the X-axis output, said difference signal constituting the Y-axis output signal. . . .

The prior art fail to teach or make such circuitry obvious. The circuitry decodes the four channel signals representing the local displacement of the pickup electrode, into three channels representing the displacement of a probe attached to the pickup electrode, in three orthogonal axes, which is more useful than the four channel signal, in which the individual channels do not directly correspond with physical axes of the transducer. The invention defined in Claim 28 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 29 requires:

. . . each of said main channel signals generated by said differential amplifier means are connected to feedback circuit means which produce feedback signals which control the amplitude of the drive plate pulses in response to displacement of the pickup electrode means relative to the drive plate electrodes, such that the induced voltage on the pickup electrode means is forced to zero, and the feedback signals generated by said feedback circuit means are proportional to the displacement of the pickup electrode means relative to the drive plate electrodes.

The prior art fail to teach or make such circuitry obvious. The feedback circuitry reduces the effect of parasitic capacitance on the linearity of the output  $V_s$  displacement signal. This is especially important here, where signals from multiple drive plate pairs are applied to a single pickup electrode, resulting in a large parasitic capacitance, in fact the parasitic capacitance in this case is several times larger than

the sense capacitance, so the non-linearity without the feedback system would be very large, on the order of 50 - 75%. The invention defined in Claim 29 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 30 requires:

. . . said feedback signals constitute the outputs of the transducer.

The prior art fail to teach or make such circuitry obvious. As the feedback signals vary in a linear manner with respect to displacement of the pickup electrode at the drive plates corresponding to each feedback signal, the feedback signals constitute useful output signals. It is possible to use external circuitry to convert these feedback signals/outputs into X-Y-Z signals, and may be desirable to do so when reducing the size or mass of the transducer is important. The invention defined in Claim 30 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 31 requires:

. . . Electrical circuit means summing all four feedback signals together, said summed signal constituting the Z-axis output of the transducer; electrical circuit means generating the difference of two of said feedback signals, said difference signal constituting the X-axis output signal of the transducer; electrical circuit means generating the difference of the two feedback signals not used to generate the X-axis output, said difference signal constituting the Y-axis output signal of the transducer.

The prior art fail to teach or make such circuitry obvious. The circuitry decodes the four channel signals representing the local displacement of the pickup electrode,

into three channels representing the displacement of a probe attached to the pickup electrode, in three orthogonal axes, which is more useful than the four channel signal, in which the individual channels do not directly correspond with physical axes of the transducer. Using the feedback circuitry to generate the four channel signals improves the linearity of the signal with respect to the displacement of the pickup electrode. The invention defined in Claim 31 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 32 requires:

. . . the test consisting of the steps of: placing the sample on the microscope stage, locating the feature or region to be tested using one or more of the optical objectives, rotating the turret to engage the precision multi-dimensional capacitive transducer, and moving the microscope stage and/or focus means to engage the probe tip with the sample and apply the desired force and/or displacement while recording said force and/or displacement.

The prior art fail to teach or make such steps obvious. This allows the optical microscope to be used to both inspect a sample to find a region or regions for mechanical inspection, and then perform the mechanical inspection on the same microscope, greatly reducing the total equipment cost. The invention defined in Claim 32 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 33 requires:

. . . a load stem and mounting bar attached to said transducer, said

mounting bar being of the proper length to position the head slider being tested directly under the load stem of the transducer when the slider suspension is attached to the mounting bar. . . .

The prior art fail to teach or make such mechanism obvious. This allows magnetic recording head sliders to be tested for tribological properties such as friction and wear without requiring special fixtures to be fabricated to mount the sliders. The sliders are mounted in such a way that the measurements correspond as much as possible to the actual operating conditions in the drive, which is required for the tests to be valid. The invention defined in Claim 33 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 34 requires:

. . . said remaining end being wider than said main central section, said remaining end section proximate said spacer means extending at least  $\frac{1}{4}$  of the width of said main section, before contacting said spacer means. . .

The prior art fail to teach or make such mechanism obvious. The wider end spreads out the force over a larger area before it is transmitted to the adhesive bond, so that the stress in the adhesive bond between the spring end and spacer is reduced, which reduces drift and hysteresis caused by excessive stress in the adhesive. The invention defined in Claim 34 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 35 requires:

. . . said spacer means and ends proximate said spacer means of said at least one support spring includes additional support means. . . .

The prior art fail to teach or make such mechanism obvious. The additional support means ( shown as the triangular features in Fig. 8) reduces the stress in the adhesive bond between the spring end and the spacers, reducing drift and hysteresis caused by excessive stress in the adhesive bond. The invention defined in Claim 35 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 36 requires:

. . . pickup electrode means comprising a centrally located center electrode containing six faces, said faces operatively grouped into three pairs, the two faces within each pair being parallel with each other and the faces of each pair being orthogonal with each of the faces of the other two pair, all of said faces connected electrically and mechanically together and composed of an electrically conductive material; six drive plates, one drive plate facing one of each face of said center electrode, means for supporting said drive plates, each of said drive plates being composed of an electrically conductive material; a plurality of support springs engaging and supporting said center electrode, said support springs arranged in a three dimensional network effective to restrict motion of said pickup electrode to the three orthogonal axes normal to the faces of said center electrode.

The prior art fail to teach or make such mechanism obvious. It is sometimes

desirable to avoid the tilting motion on which the first implementation of the invention functions, especially when the measurement consists of distances rather than or in addition to forces, as the tilting causes an interaction between the motion in the different directions. The three dimensional support spring network provides the orthogonal motion free of tilting, and the six faced pickup electrode means provides a lighter and more compact structure than that of Bonin (1235), the lighter structure being important for higher frequency response and lower vibration sensitivity. The invention defined in Claim 36 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 37 including:

. . . electrical circuit means for applying electrical drive pulses to said drive plates, said pulses having a frequency  $F$ , and pulse width  $T$  of approximately  $1/(6 \cdot F)$ , said drive pulses being grouped into three main channels, one per operative drive plate pair, there being a total of three drive plate pairs, each of said pair physically positioned on opposite faces of said center electrode, each main channel consisting of two sub-channel pulses, one sub-channel pulse of said main channel operative on one drive plate of said drive plate pair, with remaining sub-channel pulse of said main channel simultaneously operative on remaining drive plate of said operative drive plate pair, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with each main channel dedicated to a particular operative drive plate pair and with said

main channels being spaced apart in time by approximately the pulse width  $T$  sampling means for synchronously demodulating and demultiplexing the signal on the center electrode into three channels, each channel consisting of two sub-channel signals, each channel operatively associated with a particular operative drive plate pair; timing means for controlling said sampling means such that each first sub-channel is sampled during the time period that the drive pulse is applied to the corresponding drive plate and each second sub-channel is sampled after the drive pulse corresponding to that drive plate has ended, and before the drive pulse corresponding to the next channel in said multiplexed sequence is applied. . . .

The prior art fail to teach or make such circuitry obvious. The circuitry allows three axis motion of the center electrode to be measured, using a single center electrode with all faces electrically connected together, which greatly simplifies the construction, and reduces the moving mass over the design of Bonin (1235). Reduced moving mass improves the transducer performance. The invention defined in Claim 37 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 39 requires:

. . . each of said main channel signals generated by said differential amplifier means are connected to feedback circuit means which produce feedback signals which control the amplitude of the drive plate pulses in response to displacement of the center electrode, such that the induced

voltage on the center electrode is forced to zero, and the feedback signals generated by said feedback circuit means are proportional to the displacement of the center electrode.

The prior art fail to teach or make such circuitry obvious. The feedback circuitry reduces the effect of parasitic capacitance on the linearity of the output  $V_s$  displacement signal. This is especially important here, where signals from multiple drive plate pairs are applied to a single pickup electrode, resulting in a large parasitic capacitance, in fact the parasitic capacitance in this case is several times larger than the sense capacitance, so the non-linearity without the feedback system would be very large, on the order of 50 - 75%. The invention defined in Claim 39 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 41 requires:

. . . said test surface comprises a rigid disk of a magnetic disk drive data storage device

The prior art fail to teach or make such testing obvious. Mechanical testing of the head slider/disk interface is very important due to market pressure on that industry to continually increase the density of data storage, which forces reductions in head slider to disk spacing, which makes the mechanical interface between the head slider and disk more critical. The invention defined in Claim 41 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 43 requires:

. . . said pickup electrode means further comprises three interleaved flat

plates.

The prior art fail to teach or make such mechanism obvious. Three interleaved flat plates have half the mass of a hollow cube formed from six flat plates, which increases the frequency response and decreases the sensitivity to external vibration. It also allows the entire structure to be more compact than the design using the cube shaped pickup electrode, as the space that was inside the cube is accessible for use by drive plates and circuitry in the three interleaved plate design. The invention defined in Claim 43 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 44 requires:

. . . electrical circuit means for applying electrical drive pulses to said drive plates, said pulses having a frequency  $F$ , and a pulse width  $T$  of approximately  $1/F$  divided by the total number of drive plates, said drive pulses being grouped into one main channel per operative upper/lower drive plate pair, each main channel consisting of two sub-channel pulses, one sub-channel pulse operative on each drive plate, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with said main channels being spaced apart in time by approximately the pulse width  $T$ , and said two sub-channel signals of the active main channel being applied simultaneously to the top/bottom drive plate pair; sampling means for synchronously

demodulating and demultiplexing the signal on the pickup plate into one channel per drive plate pair, each channel consisting of two sub-channel signals; timing means for controlling said sampling means such that each first sub-channel is sampled during the time period that the drive pulse is applied to the corresponding drive plate and each second sub-channel is sampled after the drive pulse corresponding to that drive plate has ended, and before the drive pulse corresponding to the next channel is applied. . . .

The prior art fail to teach or make such circuitry obvious. The pulse width of approximately  $1/F$  divided by the number of drive plates allows the multiple channel drive plate signals to be multiplexed onto a single pickup electrode. The one sub-channel pulse of said main channel operative on a first drive plate of said drive plate pair, with remaining sub-channel pulse of said main channel simultaneously operative on remaining drive plate of said drive plate pair, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with each main channel dedicated to a particular drive plate pair, and with said main channels being spaced apart in time by approximately the pulse width  $T$ , allows one sample of the signal on the pickup electrode to be made while the drive plate pulse for that channel is present, and another sample for that channel to be made with no drive plate pulse present, providing a differential measurement of the amplitude (a measure of the displacement of the pickup electrode) independently for each channel. Differential measurements are helpful in rejecting some types of noise. The invention defined in

Claim 44 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 45 requires:

. . . electrical circuit means for applying electrical drive pulses to said drive plates, said pulses having a frequency  $F$ , and a pulse width  $T$  of approximately  $1/F$  divided by the total number of drive plates, said drive pulses being grouped into one main channel per operative upper/lower drive plate pair, each main channel consisting of two sub-channel pulses, one sub-channel pulse operative on each drive plate, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with said main channels being spaced apart in time by approximately the pulse width  $T$ , and said two sub-channel signals of the active main channel being applied simultaneously to the top/bottom drive plate pair; sampling means for synchronously demodulating and demultiplexing the signal on the pickup plate into one channel per drive plate pair, each channel consisting of two sub-channel signals; timing means for controlling said sampling means such that each first sub-channel is sampled during the time period that the drive pulse is applied to the corresponding drive plate and each second sub-channel is sampled after the drive pulse corresponding to that drive plate has ended, and before the drive pulse corresponding to the next channel is applied . . . .

The prior art fail to teach or make such circuitry obvious. The pulse width of

approximately  $1/F$  divided by the number of drive plates allows the multiple channel drive plate signals to be multiplexed onto a single pickup electrode. The one sub-channel pulse of said main channel operative on a first drive plate of said drive plate pair, with remaining sub-channel pulse of said main channel simultaneously operative on remaining drive plate of said drive plate pair, with said main channels being multiplexed to sequentially apply said pulses to said drive plates with each main channel dedicated to a particular drive plate pair, and with said main channels being spaced apart in time by approximately the pulse width  $T$ , allows one sample of the signal on the pickup electrode to be made while the drive plate pulse for that channel is present, and another sample for that channel to be made with no drive plate pulse present, providing a differential measurement of the amplitude (a measure of the displacement of the pickup electrode) independently for each channel. Differential measurements are helpful in rejecting some types of noise. The invention defined in Claim 45 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 48 requires:

. . . said drive plate electrodes comprise eight plates, with said two groups of drive plate electrodes comprising four plates each, further comprising: electrical circuit means summing all four main channel signals together, said summed signal constituting the Z-axis output signal; electrical circuit means generating the difference of two of said main channels, said difference signal constituting the X-axis output signal; and electrical circuit

means generating the difference of the two main channel signals not used to generate the X-axis output, said difference signal constituting the Y-axis output signal.

The prior art fail to teach or make such circuitry obvious. Eight drive plate electrodes in two groups of four, on opposing sides of said center electrode as specified in claim 46, allow the circuitry to generate four signals responsive to the local displacement of the center electrode, and the summing and differencing circuitry converts these four signals into three signals (the outputs) responsive to the X-Y-Z displacement of a probe attached to the center electrode. The invention defined in Claim 48 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 49 requires:

. . . each of said main channel signals generated by said differential amplifier means are connected to feedback circuit means which produce feedback signals which control the amplitude of the drive plate pulses in response to displacement of the pickup electrode means relative to the drive plate electrodes, such that the induced voltage on the pickup electrode means is forced to zero, and the feedback signals generated by said feedback circuit means are proportional to the displacement of the pickup electrode means relative to the drive plate electrodes.

The prior art fail to teach or make such circuitry obvious. The feedback circuitry

reduces the effect of parasitic capacitance on the linearity of the output Vs displacement signal. This is especially important here, where signals from multiple drive plate pairs are applied to a single pickup electrode, resulting in a large parasitic capacitance, in fact the parasitic capacitance in this case is several times larger than the sense capacitance, so the non-linearity without the feedback system would be very large, on the order of 50 - 75%. The invention defined in Claim 49 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 50 requires:

. . . said feedback signals constitute the outputs of the transducer.

The prior art fail to teach or make such circuitry obvious. As the feedback signals vary in a linear manner with respect to displacement of the pickup electrode at the drive plates corresponding to each feedback signal, the feedback signals constitute useful output signals. It is possible to use external circuitry to convert these feedback signals/outputs into X-Y-Z signals, and may be desirable to do so when reducing the size or mass of the transducer is important. The invention defined in Claim 50 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 51 requires:

. . . said drive plate electrodes comprise eight plates, with said two groups of drive plate electrodes comprising four plates each, further comprising: electrical circuit means summing all four feedback signals together, said summed signal constituting the Z-axis output signal; electrical circuit means generating the difference of two of said feedback

signals, said difference signal constituting the X-axis output signal; and electrical circuit means generating the difference of the two feedback signals not used to generate the X-axis output, said difference signal constituting the Y-axis output signal.

The prior art fail to teach or make such circuitry obvious. Eight drive plate electrodes in two groups of four, on opposing sides of said center electrode as specified in claim 46, allow the circuitry to generate four signals responsive to the local displacement of the center electrode. Using the feedback circuit improves the linearity of the signal to displacement, and the sum and difference circuitry converts the four signals responsive to the local displacement of the pickup electrode into three signals responsive to displacement of a probe tip connected to the pickup electrode. The invention defined in Claim 51 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 52 requires:

. . . said insulating substrate means of said drive plate assembly is composed of aluminum oxide.

The prior art fail to teach or make such mechanism obvious. Aluminum oxide is a much more mechanically stable material than the glass fiber/epoxy printed circuit board material disclosed in Bonin (1235). The stiffness is about 50 times greater, and the thermal expansion coefficient is about 1/3, so that the aluminum oxide substrate will distort much less under the influence of mechanical and thermal stresses than the glass fiber/epoxy material, resulting is a more stable transducer. The invention defined in

Claim 52 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 53 requires:

. . . at least one support spring is composed of a material having a thermal expansion coefficient similar to aluminum oxide.

The prior art fail to teach or make such mechanism obvious. This provides for the aluminum oxide substrate and the support spring(s) to expand and contract together with temperature changes, to minimize stresses between them that would distort the transducer and generate erroneous output signals. The invention defined in Claim 53 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 54 requires:

. . . at least one support spring is composed of molybdenum metal.

The prior art fail to teach or make such mechanism obvious. Molybdenum has a thermal expansion coefficient similar to aluminum oxide, which is beneficial to reduce the temperature sensitivity of the transducer. The invention defined in Claim 54 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 55 requires:

. . . said insulating substrate means of said drive plate assembly is composed of aluminum oxide.

The prior art fail to teach or make such mechanism obvious. Aluminum oxide is a much more mechanically stable material than the glass fiber/epoxy printed circuit board

material disclosed in Bonin (1235). The stiffness is about 50 times greater, and the thermal expansion coefficient is about 1/3, so that the aluminum oxide substrate will distort much less under the influence of mechanical and thermal stresses than the glass fiber/epoxy material, resulting is a more stable transducer. The invention defined in Claim 55 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 56 requires:

. . . at least one support spring and said spacer means are composed of a material having a thermal expansion coefficient similar to aluminum oxide.

The prior art fail to teach or make such mechanism obvious. This provides for the aluminum oxide substrate and the support spring(s) to expand and contract together with temperature changes, to minimize stresses between them that would distort the transducer and generate erroneous output signals. The invention defined in Claim 56 is unobvious over the cited art and Applicant requests that such claim be allowed.

Claim 57 requires:

. . . at least one support spring and said spacer means are composed of molybdenum metal.

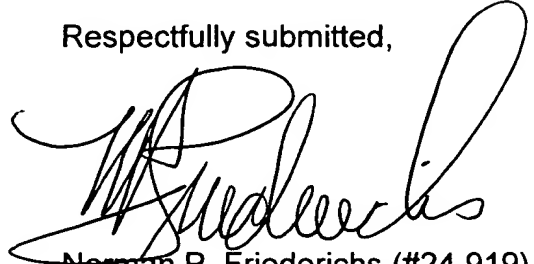
The prior art fail to teach or make such mechanism obvious. Molybdenum has a thermal expansion coefficient similar to aluminum oxide, which is beneficial by reducing the temperature sensitivity of the transducer. The invention defined in Claim 57 is unobvious over the cited art and Applicant requests that such claim be allowed.

CONCLUSIONS:

The various modifications to the claims are supported by the specification as originally filed and applicant requests entry of such amendments. The present invention, as defined in the claims as amended, is patentable over the cited art and applicant requests an early notice of allowance.

4/23/01

Respectfully submitted,



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